

The Gut Microbiome and Health

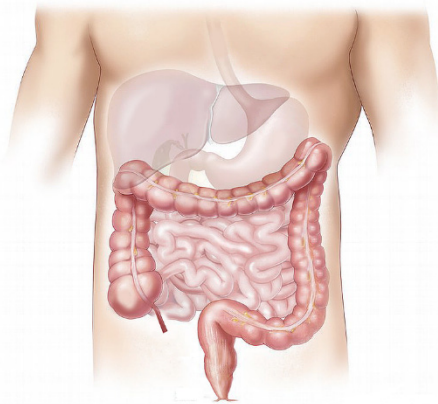
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Food and Nutrition Series | Health

by J. Clifford and T. Weir

The Gastrointestinal Tract

The gastrointestinal (GI) tract stretches from the mouth to the anus and is responsible for consuming and digesting foods, absorbing nutrients, and eliminating waste. Not only does the GI tract serve to digest food, but it also provides a physical and immunologic barrier to harmful microorganisms, foreign materials, and antigens potentially consumed with food. The gut, a term which includes the stomach and small and large intestines, is the primary site of nutrient absorption and is densely populated by microorganisms.



Cells in the small intestine have millions of tiny, finger-like projections (villi) that increase surface area of the gut to maximize nutrient absorption and provide a physical space for gut microbes to occupy. The cells that make up the large and small intestines is also populated with immune cells and other components of the immune system and are held together with protein bridges called tight junctions. These tight junctions serve as gatekeepers to regulate what can move out of the gut and into the blood.

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The Human Microbiota and Gut Microbiome

The human body, inside and out, is inhabited by an extensive number of microorganisms including bacteria, which has been a large area of interest in recent years. The vast array of microorganisms that coexist with the human host is also referred to as the microbiota. The human microbiota contains approximately 100 trillion microorganisms. That is nearly 10 times greater than the number of cells in the human body. The majority of these microorganisms present on and in the human body reside in the gut, primarily in the large intestine, which contains over 70% of the body's microbial population. These microbes, together with the functions that they carry out in the human body, are referred to as the gut microbiome.

Gut Microbiome Colonization and Establishment

The human gut is thought to be sterile at birth, with colonization occurring as the infant passes through the birth canal. However, some recent research challenges this idea, suggesting that there may be some colonization that takes place in the womb prior to birth. Initial colonization of the gut bacteria is influenced by various factors and is unique to each individual. Genetics and mode of birth (vaginal or a cesarean section) impact the microbiome. Additionally, environmental factors such as infant feeding method (breastfed vs. formula fed), introduction to solid foods, antibiotic administration, and sanitary conditions all contribute to shaping the composition of the microbiota of an individual. The infant microbiota is very dynamic, but research shows that colonization of the microbiota usually stabilizes by around age three. Later and into adulthood, the gut remains fairly stable



Quick Facts

- The human microbiota contains approximately 100 trillion microorganisms, with the majority of them residing in the large intestine.
- Microorganisms in the gut play a role in immunity, nutrition and metabolism, structure and function of the gastro intestinal tract, and can influence a number of processes outside of the gut.
- Dysbiosis is the disruption of the gut microbiota.
- A long term, plant-rich diet that is high in fiber may be one of the best ways to support gut health.
- Some fermented foods naturally contain beneficial bacteria and their metabolic products (I.e. acetic and lactic acid), which may impart health benefits to the consumer.

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and is more resilient to changes in the environment. While short term changes in the diet can cause large, transient changes in the gut microbiota, over the long term, changes in long-term dietary patterns are required to cause stable shifts in the microbiota.

The Gut Microbiome and Health

The microorganisms in the gut contribute to individual health in a variety of ways.

Immunomodulation. Gut microorganisms play a role in regulating the body's immunity. These microbes help to train our immune cells early in life by educating them on what items entering the body are foreign or harmful and which are beneficial. They can also stimulate the secretion of anti-inflammatory immune molecules to prevent over-activation of immune cells in response to the constant presence bacteria in the gut.

Nutrition and metabolism. Gut microbes also assist with the metabolism and absorption of nutrients. Through this process they produce metabolites, or byproducts. Some of these metabolites provide an important source of energy for the cells in the intestine, giving them energy to help fight off free radicals and toxins. For example, butyrate, a short chain fatty acid, provides colon cells with energy, stabilizes the tight junctions between cells, and aids in the prevention of tumor formation. Acetate, another short chain fatty acid, interacts with receptors in the body to regulate fat storage, glucose utilization, and appetite. Finally, gut microbes synthesize certain vitamins and amino acids that may contribute to human nutrition.

Physical protection. Microbes found in the gut stimulate secretion of a protective mucus layer that lines the intestinal cells and forms a protective barrier. The gut microbes will then colonize this mucus layer and competitively exclude pathogens by competing for attachment sites and nutrients in the gut, leaving less available space and nutrients for harmful microbes. Finally, some

microbes in the gut produce natural antibiotic compounds that kill foreign microbes and can produce acidic metabolites that lower the pH to create an environment that prevents pathogen growth.

Structure and function of the GI tract. Researchers have found that microbes contribute to the regeneration of cells along the villi of the intestine, contributing to increased surface area, which can help to increase nutrient absorption. Gut microbes also aid in the peristaltic activity of the gut, helping to move food down the gastrointestinal tract.

Processes outside the gut. The importance of a healthy gut microbiome extends beyond the gut. Microbes may also play a role in many activities taking place outside the gut, such as brain-gut interactions, for example, influencing the host's response to stress. Additionally, microbial products such as acetate, can travel across the intestinal and blood-brain barrier to interact with areas of the brain that help control appetite.

Dysbiosis

Maintaining diversity of gut microorganisms is key to ensuring that they can carry out the variety of roles they play in maintaining human health. This diversity helps to satisfy the needs of the gut "ecosystem." Equally important is the need for a balance of various microorganisms. When diversity and balance of microbes is lacking, the gut will be in dysbiosis. Dysbiosis is the disruption of the gut microbiota and occurs when there is an overgrowth of pathogenic microbes, loss of key microbes, and/or when there is reduced diversity in the microbial community.

The gut microbial community is impacted by factors including diet, inflammation, pathogen infections, and antibiotics use. A western diet that is low in fiber and high in fat and refined carbohydrates can negatively influence the balance of gut microbes and contribute to dysbiosis. Additionally, inflammation from diet, stress,

infections, and chronic diseases as well as pathogens can lead to a lack of diversity and imbalance in the gut. Persistent antibiotic use, especially at a young age, can destroy some of the beneficial bacteria along with the targeted harmful bacteria, also contributing to dysbiosis.

Dysbiosis affects host health in more than one way. Diarrhea, increased intestinal inflammation and abdominal pain and cramping are just a few symptoms of dysbiosis. In more serious cases, dysbiosis may play a role in the pathogenesis of various gastro intestinal disorders and diseases as well as other diseases outside of the gastro intestinal tract. Researchers have found associations between dysbiosis of the gut microbiota and inflammatory bowel disease, irritable bowel syndrome, celiac disease, obesity, diabetes, cardiovascular disease, and some cancers and central nervous system related disorders.

Supporting Gut Health

As stated previously, establishment of the microbiota begins to take place at birth, and possibly in utero. A mother's environment and exposure to microbes both prenatally and postnatally influence the establishment and colonization of her infant's gut microbiota. Additionally, mode of delivery and early feeding method impacts the microbial profile of an infant. Babies born of vaginal birth and babies who are breast fed have been shown to have a microbial profile containing a higher abundance of health-promoting microbes. While these factors contribute to the establishment of a healthy gut microbiota in early life, there are steps an individual can take to support their own gut health later in life.

Diet.

Altering long term dietary habits may be one of the most influential ways to modulate the gut microbiota. In particular, a plant based, high fiber diet including variety and moderation appears to be the most supportive of a healthy gut. Research has demonstrated that effects on the



gut from short-term changes in diet are rapid and transient, but over the long-term, diet composition continues to subtly alter gut composition throughout adulthood. Choosing many plant based, high fiber foods such as whole grains, fruits, vegetables, and legumes most of the time can help support a healthy gut.

Stress.

Chronic stress can impact our guts directly by contributing to increased inflammation as well as increased susceptibility to pathogenic organisms. Some studies have concluded that when under psychological stress, beneficial microbes are reduced in number and pathogenic microbes successfully colonize. Stress can also have an indirect influence on the gut. Often, when people are stressed they tend to eat less healthfully, consuming more highly refined, high sugar, and high fat foods, which may have negative consequences for the gut. Minimizing stress can have a positive impact on the gut microbiota. Setting aside time for relaxation, exercising regularly, and getting adequate sleep are just a few ways to help alleviate stress.

Antibiotics.

Antibiotic use is necessary and very helpful in many situations. However, when used, some of the beneficial bacteria in the gut get eliminated along with the targeted harmful bacteria. For this reason, it may be advantageous to help restore the gut microbiota by consuming foods containing probiotics and prebiotics or taking a probiotic supplement, if deemed appropriate. Researchers have found that in adults the gut microbial profile tends to return to the original balance approximately two weeks after the use of antibiotics, provided it is short term and non-

recurring. However, taking a probiotic may help prevent pathogens from recolonizing during this vulnerable recovery period.

Probiotics and Prebiotics.

Consuming foods containing probiotics and prebiotics contribute to a healthy gut. Read more about probiotics and prebiotics below.

Stool transplants.

Stool transplants are not necessary for everyone to support a healthy gut, but they are an effective and useful method of combating *Clostridium difficile* infections. Researchers found that using fecal microbiota transplantation can be as effective as, if not more effective than, antibiotics in treating patients with *C. difficile*, which causes symptoms similar to Crohn's disease. Researchers continue to study the effects of fecal transplants as a therapy for various gut related diseases and disorders, such as IBD and Type 2 diabetes.

Probiotics, Prebiotics and Synbiotics

Probiotics

Probiotics are live microorganisms that when consumed in adequate amounts, confer a health benefit on the host. They are consumed in foods or in supplement form. Probiotics are naturally found in fermented foods like yogurt, kefir, miso, tempeh, kombucha, kimchi, sauerkraut, and lacto-fermented vegetables. There is limited research on the health benefits of fermented foods, and more conclusive evidence is needed.



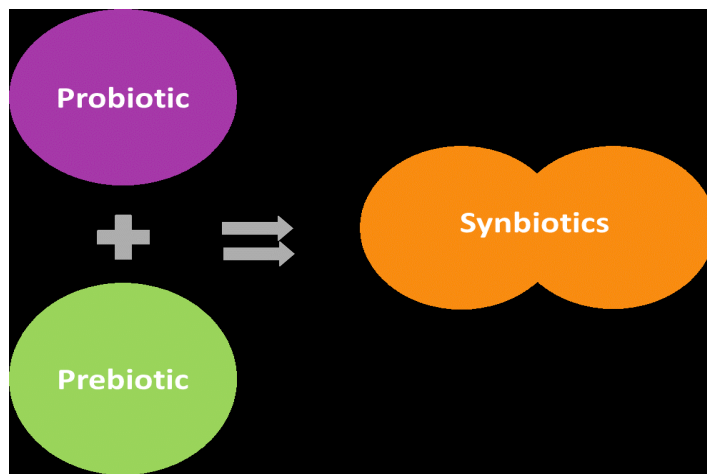
While many of the specific organisms present in these foods have not specifically been shown to have

beneficial health effects, the microbial byproducts present in fermented foods (particularly vegetables, non-alcoholic fermented vegetables, and dairy) can reduce pathogen growth and promote health. Fermented foods can be consumed as part of a healthy diet, and the interest in fermenting foods and consuming fermented foods has increased dramatically in the last 10 years.

As dietary supplements, probiotics are available in powder, capsule, tablet, or packet form. Probiotics are also added to some food products during processing. Probiotics in dietary supplements or foods are present as a single species or as a mixture of several different probiotic species. The two most common types of probiotics used in the United States are *Lactobacillus* and *Bifidobacterium*. There are many different species of bacteria that fall in each of these broad groups. The yeast *Saccharomyces boulardii* is also widely used as a probiotic. Probiotics are commonly used for a variety of gastrointestinal conditions including antibiotic-associated diarrhea, infectious diarrhea, IBD or inflammatory bowel disease which includes Crohn's disease and ulcerative colitis, as well as IBS or irritable bowel syndrome. The beneficial effects of probiotics are specific to particular probiotic strains and the health effects of one strain may not apply to other strains. To know what a probiotic can do, you need to know the strain. For example, *Bifidobacterium infantis* strain 35624 has beneficial effects specific for those with irritable bowel syndrome.

Prebiotics

Prebiotics are not the same as probiotics. Prebiotics are non-digestible dietary fibers that increase the growth of specific organisms in the gut. Essentially, they are the fuel for the probiotics or good bacteria in the gut. Consuming prebiotics leads to specific changes in the composition and/or activity in the microbiota in the gut conferring health benefits on the host. Prebiotics include the oligosaccharides inulin, fructooligosaccharide or FOS, and galactooligosaccharide or GOS. These oligosaccharides are



naturally found in human breast milk and in different foods like Jerusalem artichokes, onion, jicama root, leeks, and asparagus. Fiber in foods like bananas and legumes can also act like prebiotics. Fiber in oats, barley, and apples can be fermented into short chain fatty acids by certain bacterial species in the gut and used for energy. As well as being found in foods, prebiotics can also be consumed in supplement form. Prebiotics can be supplemented alone or in combination with probiotics, which is referred to as synbiotics. When consumed together, probiotics and prebiotics act synergistically, potentially providing even further health benefits.

Are probiotics and prebiotics recommended?

Probiotic supplements may not be necessary if an individual does not suffer from any gut related problems. Consuming probiotics and prebiotics from foods that naturally contain them may be a good option and easier on the budget for gut health maintenance.

The research on probiotics is ongoing and while many products containing probiotics are marketed for different uses, the FDA has not approved any general health claims for probiotics. A few probiotics, such as VSL3, have medical food status, which means that it can be used to treat specific health issues and there is a minimum of one human clinical trial to support efficacy. Before using probiotic supplements, ask your healthcare provider if taking probiotics is right for you. If you are pregnant or nursing, consult your healthcare provider before taking probiotics. If you want to give

probiotics to your child, contact your child's healthcare provider first. If you have a serious health problem and you're taking probiotics, be sure to tell your healthcare provider that you are taking them so they can monitor you for negative side effects.

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